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AUTHOR(S):

Imaeda, Tatsuhiro; Furukawa, Akira; Onuki, Akira

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Viscoelastic Phase Separation in Shear Flow

Aichi Gakusen Univ. Tatsuhiro Imaeda

Dept. of Physics, Kyoto Univ. Akira Furukawa, Akira Onuki

シア流下にある高分子溶液の粘弾性相分離について、polymer volume fraction と conformation tensor を gross variables とした TDGL モデルを数値的に解いて得た結果を報告する。

We numerically investigate viscoelastic phase separation in polymer solutions under shear using a time-dependent Ginzburg-Landau model in two dimensions. The gross variables in our model are the polymer volume fraction and a conformation tensor. The latter represents chain deformations and relaxes slowly on the rheological time giving rise to a large viscoelastic stress. Below the coexistence curve, interfaces appear with increasing the quench depth and the solvent regions act as a lubricant. We find steady two-phase states composed of the polymer-rich and solvent-rich regions, where the characteristic domain size is inversely proportional to the average shear stress for various shear rates.

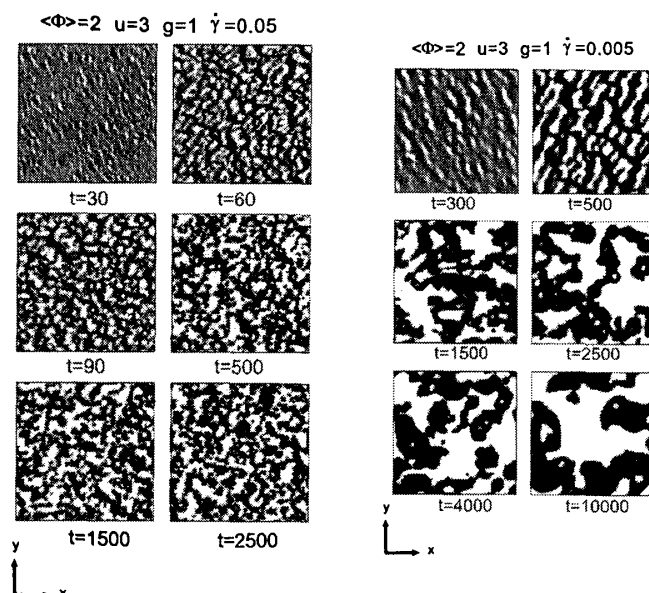


Figure 1: Time evolution of the scaled polymer volume fraction $\Phi(\mathbf{r}, t)$ at $\dot{\gamma} = 0.05$ (left) and $\dot{\gamma} = 0.005$ (right) for $u = 3$, $\langle \Phi \rangle = 2$, and $g = 1$ below the spinodal curve.

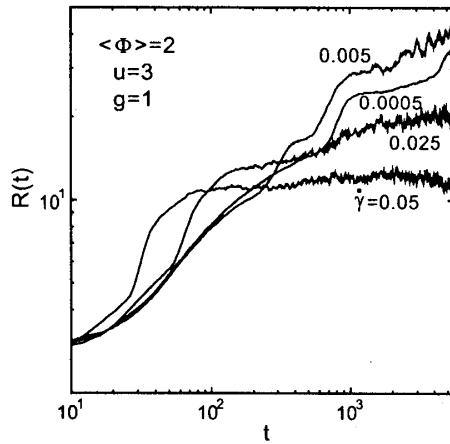


Figure 2: Time evolution of the domain size $R(t)$ below the spinodal curve for $g = 1$, $u = 3$, and $\langle \Phi \rangle = 2$. Here $\dot{\gamma} = 0.0005, 0.005, 0.025$, and 0.05 . At small shear rates flow-induced coagulation accelerates the domain growth as demonstrated by the curve of $\dot{\gamma} = 0.005$. For $\dot{\gamma} \gg 0.005$, shear-induced domain breakup becomes dominant and dynamical steady states are realized at smaller domain sizes.

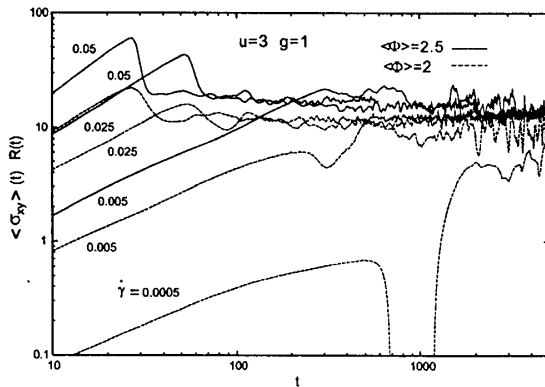


Figure 3: Time evolution of $\langle \sigma_{xy} \rangle(t) R(t)$ below the spinodal curve at various shear rates for $g = 1$ and $u = 3$. Here $\langle \Phi \rangle = 2$ (solid lines) or $\langle \Phi \rangle = 2.5$ (dotted lines).

References

- 1) T. Imaeda, A. Furukawa, and A. Onuki, Phys. Rev. E (2004), 051503.
- 2) A. Onuki, *Phase Transition Dynamics*, (Cambridge University Press, Cambridge, 2002).